

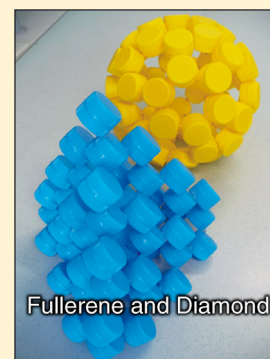
Building Molecular Models Using Screw-On Bottle Caps

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S Supporting Information

ABSTRACT: Chemical models can be built using screw-on bottle caps. Two identical caps can be joined together by thermal welding to form atoms, and the resulting atoms can be joined together by welding or by hot polymer glue to form molecules. The method is easy, can be applied at every level of chemical education, and gives access to an unlimited number of models at almost no cost. It inspires hands-on activity of pupils and can be used to show the dependence between the three-dimensional structure of molecules and their chemical, physical, and biological features.



KEYWORDS: Hands-On Learning/Manipulatives, Atomic Properties/Structure, Molecular Modeling, Stereochemistry

Chemistry is the study of substances, their properties, and changes. To understand the concept of a substance, not only should its molecular composition be known but also the three-dimensional arrangement of its atoms. Modern chemistry and molecular biology focus on the asymmetry and stereochemistry of molecules. This poses a challenge as to how to introduce students to the world of atoms and molecular interactions so that they can understand the properties of molecules resulting from the spatial arrangement of atoms.^{1–3} As didactic tools, various molecular models are applied using computer visualization. However, this requires professional programs or model sets.^{4–6} There is, therefore, a need for a convenient, accessible, and inexpensive method of building molecular models.^{7–9} In this communication, a simple method for preparing chemical models using plastic caps is described.

MATERIALS

- Screw-on bottle caps of various sizes and colors (gathered from available household recyclables)
- A source of small flame (preferably a small spirit burner)
- Electric soldering iron (or a piece of wire and a pair of pliers, or a wire stuck in a cork)
- Thermoplastic glue (recommended for plastics, or all-purpose glue)
- Glue gun
- Office knife cutter

PROCEDURE

Atom Construction

Remove the edges of the plastic caps using office knife cutter. Stack two identical plastic caps together by hand. Melt the stacked edges of the plastic caps at 1 cm intervals around the

caps using an electric soldering iron or a piece of wire heated by a flame to join the caps (Figure 1A).

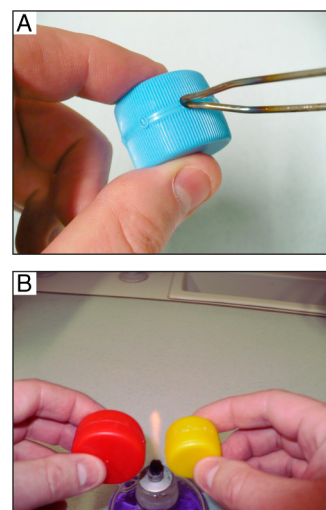


Figure 1. Preparation of a model using screw-on bottle caps: (A) the joining of two caps and (B) atom connection using a burner flame.

Model Construction

Method A. Using a small flame spirit burner, soften the edges of the model atoms in the flame and stick together (Figure 1B). Let the material cool. To provide a strong joint, it is important to soften the edges of the model atoms simultaneously.

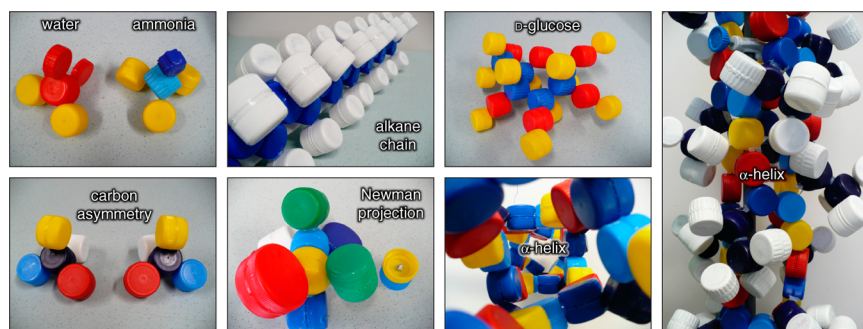


Figure 2. Selected examples of screw-on bottle cap models.

Method B. Warm thermoplastic glue in a hot glue gun, put a drop of hot glue on one atom, and stick to another atom. Let the glue cool to fix the model.

HAZARDS

Standard safety procedures should be applied when using a flame source in a laboratory, and a fire extinguisher should be kept close at hand. The plastic caps are very hot at the moment of junction. If the hot caps come into contact with skin, rinse with copious amount of water. The work should be carried out using a fume hood as there will be a small amount of vapor from the melting plastic and (if used) hot glue. It should be noted that standard kitchen equipment is satisfactory. If using a small piece of wire instead of a soldering iron, hold the wire by sticking it in a cork.

DISCUSSION

The main advantage of this method is the access it gives to unlimited numbers of chemical models at almost no cost. The method can be used at every level of education, and its application is limited only by imagination. In addition, models can be made by students at home in the form of a project, which is a valuable manual activity.

Plastic bottle caps, a common recycling material, are easily accessible in various colors and dimensions. They are excellent for modeling different types of atoms. Plastic caps are made of polyethylene, which displays poor gluability (adhesiveness). In contrast, polyethylene is a thermoplastic material, so it can be joined by welding. The models obtained in this way are quite stable. The thermal joint is relatively strong, and once prepared, the models should last for a number of years. Bigger models also can be made; however, greater (heavier) atom groups should not be attached by a single joint as they have a tendency to disconnect. The model atoms can also be joined using hot polymer glue. The joint is somewhat weaker than a thermal junction, but this can be advantageous if mistakes are made during the preparation of bigger models because the atoms can be disconnected without any deformation.

Some example applications are shown in Figure 2. The geometry of molecules can easily be explained if electron pairs are represented using a single cap, as in water or ammonia. The alkane chain looks different than when drawn on a flat piece of paper; thus, hydrophobic features can be discussed. The asymmetry of the carbon atom can easily be explained if it is shown that four different substituents can be displayed in two ways. The position of the hydroxyl groups in the space around the β -D-glucose ring gives a possible explanation why it is the most commonly occurring monosaccharide in nature.¹⁰ At the higher educational level, rotation around a single bond, as in a

Newman projection, can be modeled if the mobile bond is made using a small screw. Building complex models, such as an α helix, diamond, or fullerene (see the graphical abstract), is somewhat time-consuming, but the final model can serve as a didactic tool for many years, and there is no need to use several professional modeling sets. The method is also an excellent homework project. In testing the method, models of natural fragrances¹¹ were successfully built as homework projects by a group of high school (17-year-old) students.

ASSOCIATED CONTENT

Supporting Information

Patterns and tips for model building. This material is available via the Internet at <http://pubs.acs.org>.

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Notes

The authors declare no competing financial interest.

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